1.22 ELEMENTAL QUANTIFICATION OF AIRBORNE PARTICULATE MATTER IN BANDUNG AND LEMBANG AREA*

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ABSTRACT

ELEMENTAL QUANTIFICATION OF AIRBORNE PARTICULATE MATTER IN BANDUNG AND LEMBANG REGION: The contaminated airborne particulates by toxic gases and elements have a potential affect to the human health. Some toxic elements related to air pollution have carcinogenic affect. The quantification of those elements is important to monitor a level of pollutant contained in the airborne particulate. The aim of this work is to analyze the air particulate sample using instrumental neutron activation analysis and other related technique. Two sampling points of Bandung and Lembang that represent an urban and rural area respectively have been chosen to collect the air particulate sample. The samplings were carried out using Gent Stacked Filter Unit Sampler for 24 hours, and two cellulose filters of 8 μm and 0.45 μm pore size were used. Trace elements in the sample collected were determined using NAA based on a comparative method. Elemental distribution on $PM_{2.5}$ and PM_{10} fraction of airborne particulate was analyzed, the enrichment factor was calculated using Al as reference elements, and the black carbons contents were determined using EEL Smoke Stain Reflectometer analyzed. The results are presented and discussed.

Keywords: *$PM_{2.5}$, PM_{10}, Black Carbon, Enrichment Factor, Pollutant, Airborne Particulate Matter.*

INTRODUCTION

Air pollution monitoring, especially in big cities and industrial areas, is important for several reasons. More and more aerosols and toxic gases are released to the atmosphere due to the rapid development of industrialization and urbanization,

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which lead to the increase of vehicles used for transportation. The release of aerosols may affect the human health, because it contains toxic elements and heavy metals, which contaminate the air, rainwater, and soils [1]. In order to know the source of pollutant, valid data on the elemental composition of aerosols is needed. This data is reflected by the elemental composition in airborne particulate samples taken from different area.

Instrumental neutron activation analysis (INAA) is one of the most widely used for elemental quantification in airborne particulate sample for its high sensitivity and versatility, in addition to the high accuracy and precision [2,3,4]. This analysis technique is very suitable for our airborne particulate sample, since our sample, which has been obtained by using Gent Stacked Filter unit sampler, is around 1 mg/filter for fine or coarse airborne particulate. INAA as non-destructive analysis technique can compete with, Proton Induced X-ray Emission (PIXE) and Energy Dispersive X-ray Fluorescence (EDXRF). Therefore, INAA is our choice since the analysis technique is already available.

Samples taken from Centre For Research and Development of Nuclear Technique in Bandung (urban area) and Meteorological and Geophysical Agency in Lembang (rural area). Bandung is province city of West Java categorized as industrial city with high populated of people and cars, whereas Lembang is suburb city 20 km away from sampling site in Bandung. Information on pollution levels in this area and trends over time provides a valid and scientifically based support to relevant regulatory body in making decisions to minimize the increase health risk of persons in these populated areas.

METHODOLOGIES

Sampling

Samplings of airborne particulate were carried out for 24 hours using Gent Stacked Filter Unit Sampler. The stacked Filter Unit sampler consists of fine and coarse filter that have 47 mm diameter, 0.45 μm, and 8 μm pore size. Airborne particulate matter will be deposited on 8 μm and 0.45 μm pore size filter for coarse and fine particulate respectively.

Sampling was carried out only in Centre for Research and Development of Nuclear Technique in Bandung (urban area) and Meteorological and Geophysical Agency in Lembang for rural area. In Centre For Research and Development of Nuclear Technique sampling of airborne particulate was carried out by placing the Gent sampler on the roof of the second floor of the building A about 8 m above ground level and 60 m from the nearby street of this research centre. In Meteorological and Geophysical Agency sampling of airborne particulate was carried out by placing Gent sampler on the roof of the Agency building about 6 m above ground level and about 1 km from nearby street. Exposed and unexposed filters were equilibrated in the chamber of 45-55 % of humidity and weighed in semi microbalance before using. Airborne particulate samples were placed in clean polyethylene bag.

Analysis

The elemental concentrations in airborne particulate are determined by neutron activation analysis. Samples irradiations were carried out in Serpong for short-lived radionuclides. Standards for short-lived radionuclide are prepared by pipetting suitable mixed of SPEC PURE standard solution onto Whatman filter paper no. 41 and dried using infrared. The elemental content are determined by irradiating the samples and standards for one minutes and counted directly using γ-ray spectrometer coupled with Accuspec. Gamma rays spectra from Accuspec were analyzed using Aptec OSQ/Professional.

Enrichment factor was calculated using Mason's crustal abundances [6], whereas Black Carbon (BC) was determined using EEL Smoke Stain Reflectometer as recommended by W. Maenhaut and D. Cohen [5].

RESULTS AND DISCUSSION

Mass concentration of APM

Figure 1 shows the monthly average concentration of $PM_{2.5}$, PM_{10} and BC as a function of sampling time, from January 2002 to November 2002. The distribution of $PM_{2.5}$ and PM_{10} depend on the sampling time for both sampling point. They were under the influence of the weather. Meanwhile the black carbon is independent to the sampling time. These mean that the black carbon was released by a fixed sources on this region. The mass concentration of $PM_{2.5}$ was in the range of 9.6 $\mu g/m^3$ to 24.2 $\mu g/m^3$ and that the PM_{10} was in the range of 33 $\mu g/m^3$ to 66 $\mu g/m^3$ for the urban area (Bandung). Whereas the mass concentration of $PM_{2.5}$ was in the range of 3.5 $\mu g/m^3$ to 11.2 $\mu g/m^3$ and PM_{10} was in the range of about 4.0 $\mu g/m^3$ to 14.0 $\mu g/m^3$ for rural area (Lembang) which are lower that than of urban area (Bandung). These data much lower than that of National Ambient Air Quality Standard (NAAQ) for 24-hour average, 65 $\mu g/m^3$ and 150 $\mu g/m^3$ for PM 2.5 fraction and PM_{10} fraction respectively.

Figure 2 and 3 show the correlation of PM_{10} and $PM_{2.5}$ for both sampling area (urban and rural area). The results showed a phenomenon that have in contradiction. The obtained PM_{10} and $PM_{2.5}$ data for the period of January 2002 – November 2002 indicate a strong correlation (R^2 = 0.9157) for Lembang sampling point, whereas the result of Bandung sampling point is the opposite (R^2 = 0.1956).

Correlation analysis of black carbon with PM_{10} and $PM_{2.5}$, we presented in the Figure 4 and 5 for urban area (Bandung), and Figure 6 and 7 for rural area (Lembang). All resulted analysis show a weak correlation for APM obtained at urban area (R^2 = 0.264 and R^2 = 0.373 respectively) and strong correlation for that in the rural area (R^2 = 0.697 and R^2 = 0.6636 respectively). Correlation among $PM_{2.5}$, PM_{10} and black carbon explained that PM_{10} of Bandung city(urban area) influenced by coarse fraction, whereas PM_{10} of Lembang (rural area) influenced strongly by antrophogenic source.

Enrichment factor

As mention before, the Enrichment Factor (EF) was calculated from measured elements using Mason's crustal abundances for the sampling period using

$$EF = [(X_i/C_i)_{APM}/(X_i/C_i)_{REF}]$$

Where X_i = element of interest and C_i = reference element. The Al was used as reference element because it is supposed to be unique elements in soil. Table 1 and 2 show the elemental quantification of Al, Br, Cl, Mg, Mn, Na and V of $PM_{2.5}$ fraction taken from Bandung and Lembang sampling point. Meanwhile, Table 3 show the calculated EF for seven selected elements of Na, V, Mn, Br, Cl, and Mg contained in the sample taken from the urban area. The EF value of Br and Cl are higher compare to the other. This higher value indicated that they are not of crustal origin and they are assumed to be anthropogenic elements. The same case is obtained for the urban area (Table 4). The EF value of Br and Cl are higher than the other. We estimate that the Br was released by fuel of the automotive, whereas the Cl probably coming from the utilization of fertilizer.

Black carbon in APM.

The monthly average concentrations of Black Carbon were determined according to suggested method [7, 8] and the obtained result show on the Table 5. The quantity of BC was calculated using formula of

$$BC\ (\mu g/cm^2) = [100/2F.e]\ Ln\ [Ro/R]$$

F indicate of correction factor of order 1, e is the mass attenuation coefficient (m^2/g), R_o and R are the unloaded and loaded filter reflectance respectively for a given wavelength.

The average concentrations of Black Carbon in urban and rural area are in the range of 3.4 $\mu g/m^3$ to 6.1 $\mu g/m^3$ and 1.3 $\mu g/m^3$ to 4.7 $\mu g/m^3$ respectively.

CONCLUSION

- The concentrations of $PM_{2.5}$ are much lower than the value of National Ambient Air Quality Standard (NAAQ) for 24-hour average.
- The quantity of Br and Cl were enriched, both for Bandung and Lembang, whereas V trend to increase.
- The concentration of Black Carbon independent to the time. It probably were released from antrophogenic sources

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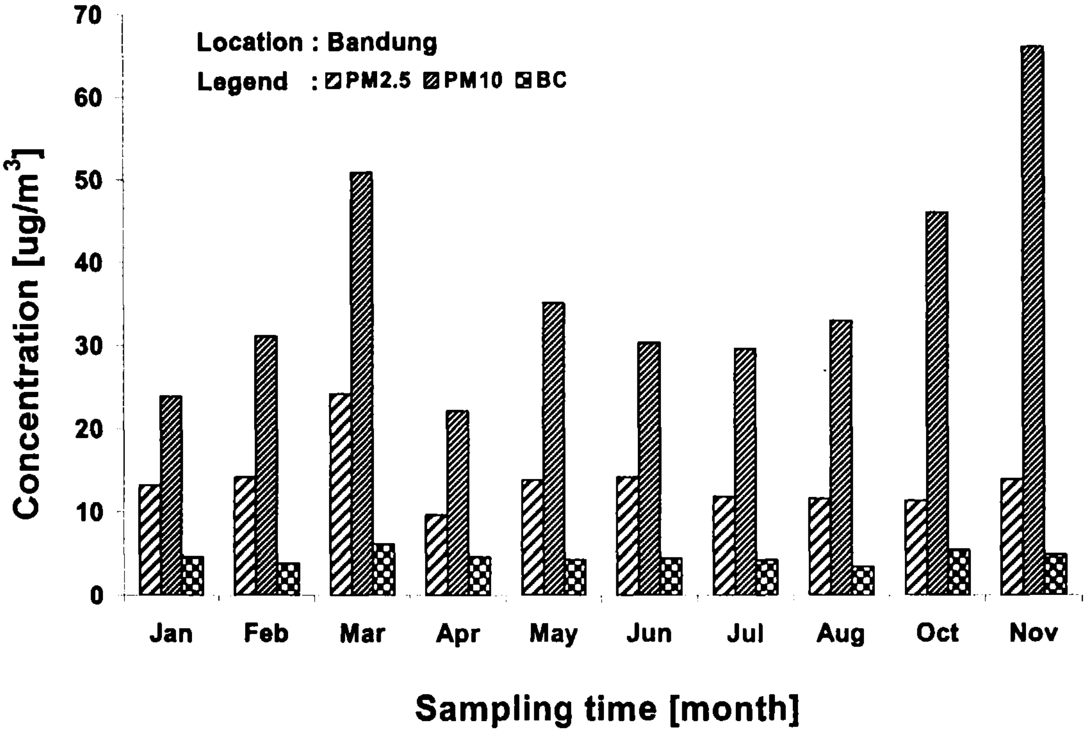

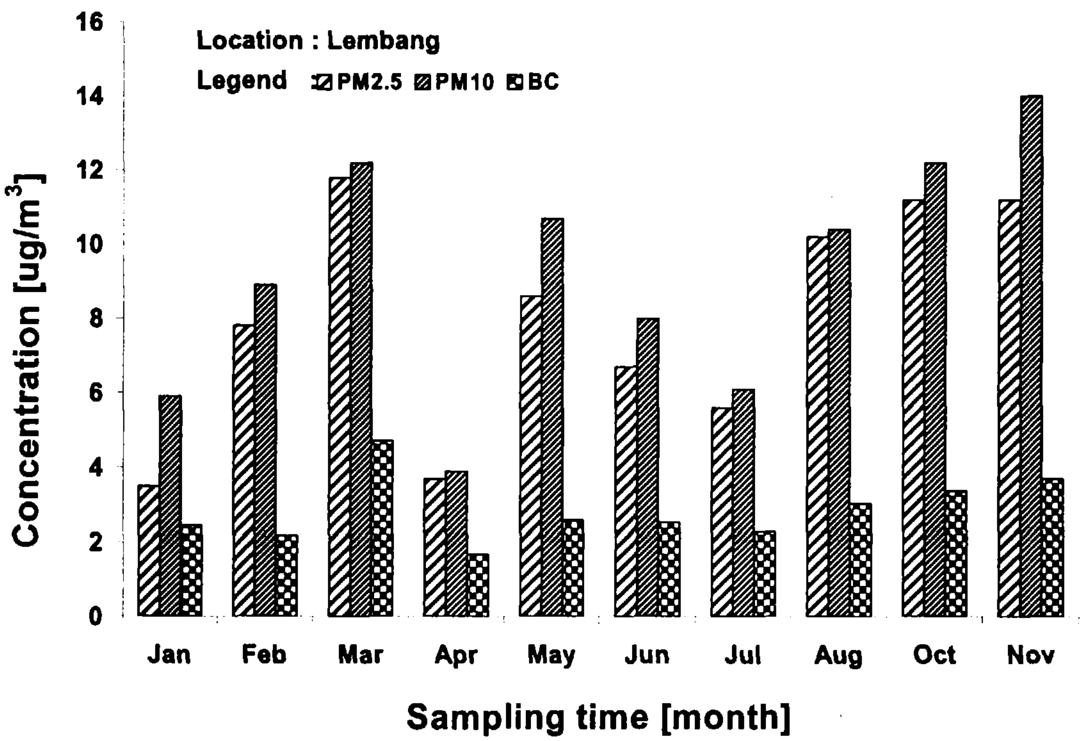

Figure 1. Monthly average of $PM_{2.5}$, PM_{10} and Black Carbon at Bandung (above) and Lembang (below) area on the period of January – November 2002.

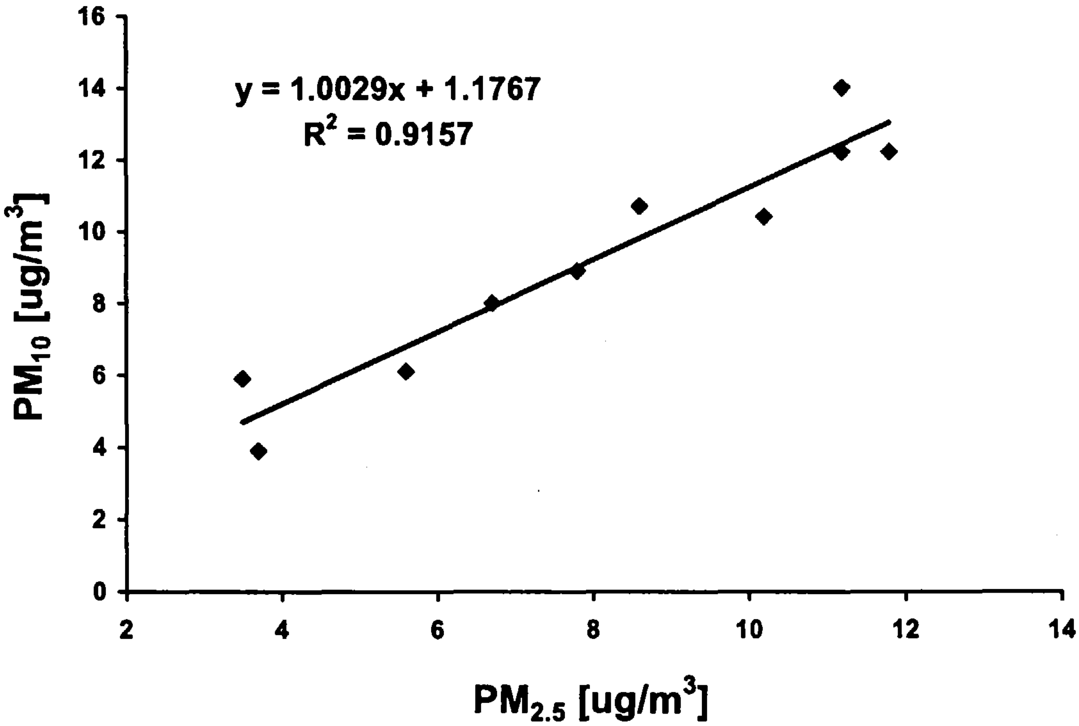

Figure 2. Relation of PM_{10} versus $PM_{2.5}$ gravimetric masses for air particulate sample taken from Lembang sampling point.

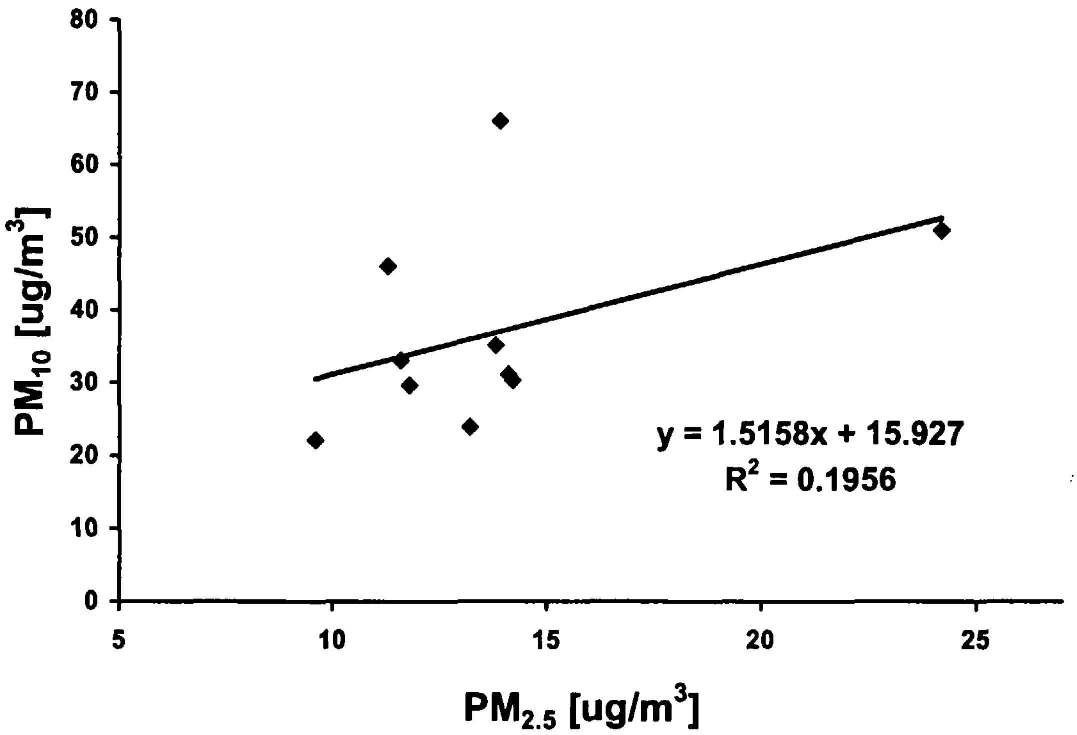

Figure 3. Relation of PM_{10} versus $PM_{2.5}$ gravimetric masses for air particulate sample taken from Bandung sampling point.

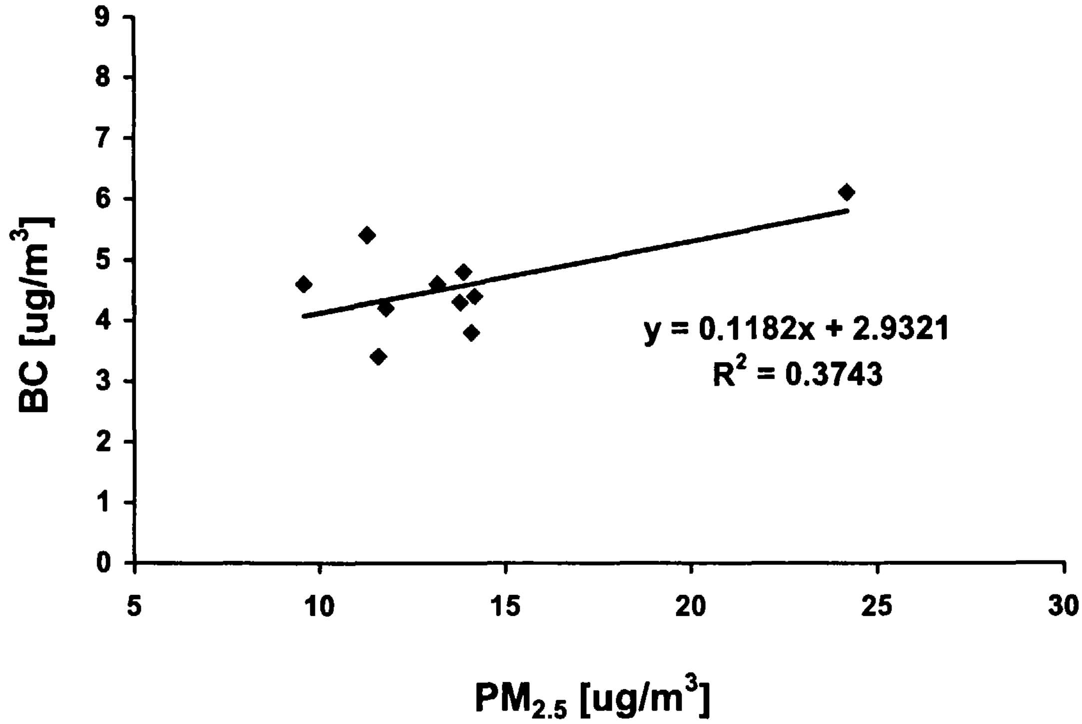

Figure 4. Correlation of Black Carbon to $PM_{2.5}$ for Bandung sampling point

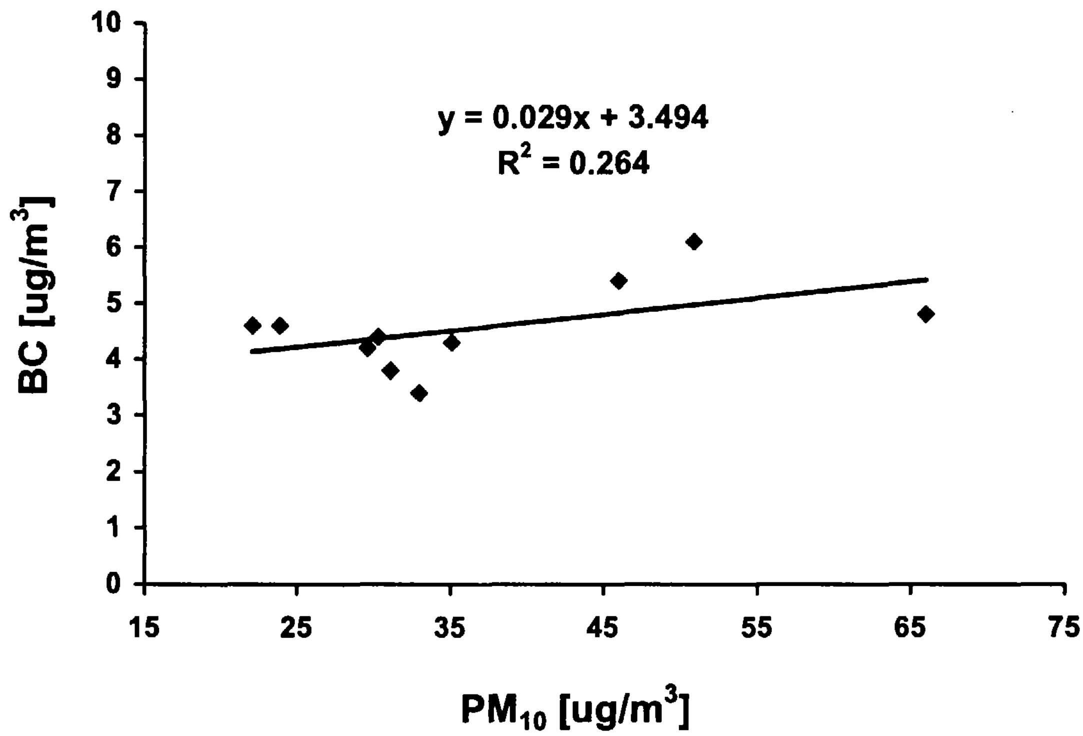

Figure 5. Correlation of Black Carbon to PM_{10} for Bandung sampling point

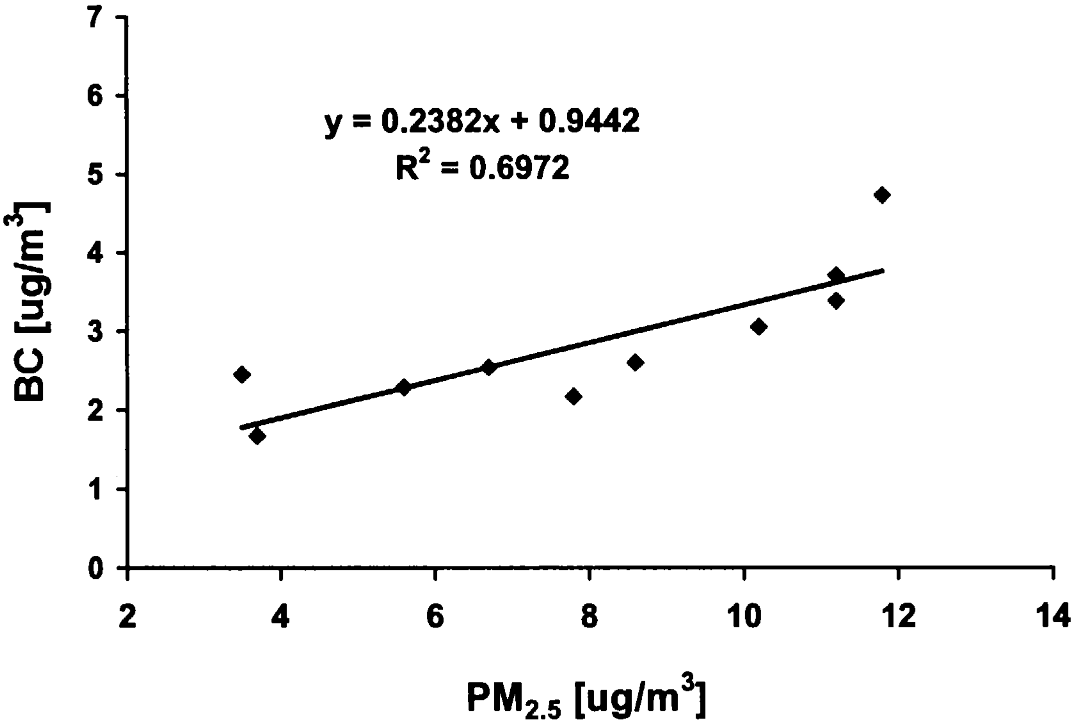

Figure 6 : Relation of Black Carbon to $PM_{2.5}$ for Lembang Area.

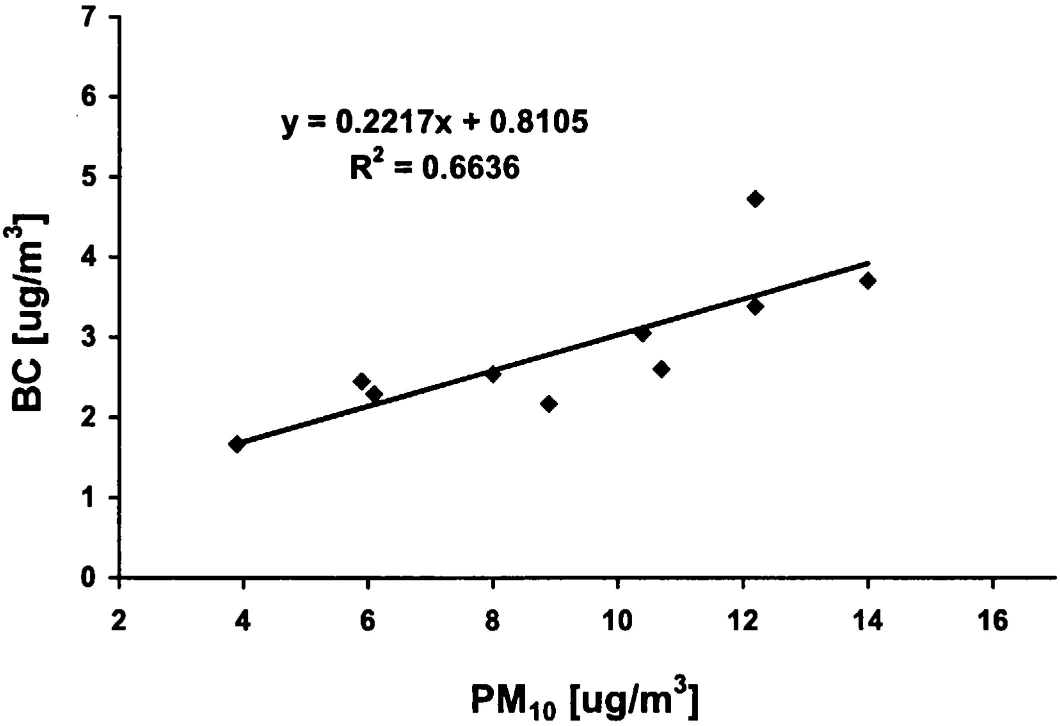

Figure 7 : Relation of Black Carbon to PM_{10} for Lembang Area.

Table 1. Average elemental concentration of $PM_{2.5}$ for Bandung sampling point.

Month	Elementary concentration, [μg/m³]						
	Al	Br	Cl	Mg	Mn	Na	V
Jan	47	27	56	< 149	1	69	0.8
Feb	38	53	63	< 71	2	62	0.8
Mar	62	57	139	-	2	51	2.1
Apr	109	-	14	-	1	25	-
May	113	-	-	-	2	45	0.6
Jun	-	-	26	-	3	51	1.7
Jul	-	-	29	-	1	99	1.3

Table 2. Average elemental concentration of $PM_{2.5}$ for Lembang sampling point.

Month	Elementary concentration, [μg/m³]						
	Al	Br	Cl	Mg	Mn	Na	V
Jan	13	24	56	< 53	0.5	12	0.2
Feb	13	24	65	<143	0.7	23	2.4
Mar	13	49	87	-	0.7	-	0.6
Apr	43	49	26	-	0.6	46	0.8
May	26	15	-	<77	-	-	Nd

Table 3. Enrichment factor of elements of aerosol from Bandung area (urban area) are based on Al as reference element.

Month	Na	V	Mn	Br	Cl	Mg
Jan	4	10	3	18682	745	7
Feb	5	13	3	45357	872	6
Mar	2	20	3	99134	1402	Nd
Apr	1	Nd	0.4	4177	80	Nd
May	1	3	1	No data	No data	Nd
June	1	6	1	No data	100	Nd
July	1	2	0.2	No data	76	Nd

Table 4. Enrichment factor of elements of $PM_{2.5}$ in Lembang area are based on Al reference element.

Month	Na	V	Mn	Br	Cl	Mg
Jan	7	14	3	60037	2694	9
Feb	5	14	5	60000	3125	9
Mar	2	19	5	122575	4185	Nd
Apr	3	1	1	37057	378	Nd
May	1	Nd	2	18762	289	8

Table 5. Black Carbon analysis result in $PM_{2.5}$ of Bandung and Lembang Area

Month	Bandung area		Lembang area	
	Black C [μg/m^3]	% Black C	Black C [μg/m^3]	% Black C
Jan	4.6	36	2.5	51
Feb	3.8	27	2.2	32
Mar	6.1	25	4.7	43
Apr	4.6	43	2.1	39
May	4.3	35	2.6	33
June	4.4	34	2.5	39
July	4.2	35	2.3	44
Aug	3.4	38	3.1	30
Oct	5.4	40	3.4	33
Nov	4.8	24	1.3	35